Research Report

The World of Emotions Is Not Two-Dimensional

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ABSTRACT—*For more than half a century, emotion researchers have attempted to establish the dimensional space that most economically accounts for similarities and differences in emotional experience. Today, many researchers focus exclusively on two-dimensional models involving valence and arousal. Adopting a theoretically based approach, we show for three languages that four dimensions are needed to satisfactorily represent similarities and differences in the meaning of emotion words. In order of importance, these dimensions are evaluation-pleasantness, potency-control, activation-arousal, and unpredictability. They were identified on the basis of the applicability of 144 features representing the six components of emotions: (a) appraisals of events, (b) psychophysiological changes, (c) motor expressions, (d) action tendencies, (e) subjective experiences, and (f) emotion regulation.*

Reduction of complex data sets involving a large number of measures to a few meaningful underlying dimensions is common in many branches of science. For example, the perception of color is described by the dimensions of brightness, hue, and saturation. For more than half a century, emotion researchers have attempted to establish the underlying dimensional space that most economically accounts for the similarities and differences in emotional experience, and there has been considerable disagreement about the number and nature of the dimensions that provide an optimal framework for studying emotions. Most early research suggested at least three dimensions, commonly evaluation-pleasantness, potency-control, and activation-arousal

(e.g., Osgood, May, & Miron, 1975). Although many recent researchers have focused exclusively on two-dimensional models, such as the valence-arousal model (e.g., Yik, Russell, & Feldman-Barrett, 1999), the search for the optimal low-dimensional representation of the emotion domain remains open.

Past work has primarily derived dimensions of emotion from the perceived similarity of emotion labels or facial expressions (e.g., Fontaine, Poortinga, Setiadi, & Suprapti, 2002; Schlosberg, 1952; Shaver, Schwartz, Kirson, & O'Conner, 1987), or from individual differences in verbal descriptions of emotional experiences (e.g., Yik et al., 1999), and the dimensions have often been derived in an atheoretical manner. In contrast, the work reported here started from the widely shared theoretical conceptualization of emotions as consisting of variably interrelated changes in activity across a set of six components: (a) appraisals of events, (b) psychophysiological changes (bodily sensations), (c) motor expressions (face, voice, gestures), (d) action tendencies, (e) subjective experiences (feelings), and (f) emotion regulation (Ellsworth & Scherer, 2003; Niedenthal, Krauth-Gruber, & Ric, 2006; Scherer, 2005). No previous studies have included all six of these components, and most have included only one or two. To obtain definitive evidence concerning the optimal low-dimensional space, we used a semantic-profile approach (Scherer, 2005), asking participants from three different Indo-European language groups (English, French, and Dutch) to evaluate 24 prototypical emotion terms on scales representing 144 features that represent activity in all six of the major components of emotion (Ellsworth & Scherer, 2003).

METHOD

Instrument

For this study, we used a new instrument originally constructed in English, the GRID instrument (Scherer, 2005). The GRID consists of a Web-based questionnaire composed of 24 emotion terms and 144 emotion features. The 24 terms are prototypical emotion terms commonly used in both emotion research and

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daily language. This representative set was chosen on the basis of frequent use in the emotion literature, consistent appearance in cross-cultural free-listing and prototypicality-rating tasks, and frequent mention in the self-reports from a large-scale Swiss household study of people's descriptions of an emotional situation they experienced the previous day (Scherer, Wranik, Sangsue, Tran, & Scherer, 2004). The 144 emotion features operationalize activity in each of the six emotion components (see Table 1). Thirty-one features refer to appraisals, 18 to bodily experiences, 9 to facial expression, 12 to vocal expression, 5 to gestural expression, 40 to action tendencies, 22 to subjective feelings, and 4 to regulation. An additional 3 features represent other qualities, such as frequency and social acceptance. The features were derived from a broad range of very diverse emotion theories and literature, such as the appraisal theory of Scherer (2001), the psychophysiological emotion literature (Stemmler, 2003), the action-tendency theory of Frijda (Frijda, Kuipers, & Terschure, 1989), the current-affect theory of Russell (Yik et al., 1999), and the expression-regulation theory of Ekman and Friesen (1969). The English GRID instrument was translated into French and Dutch by means of the translation/back-translation procedure.

Procedure

The GRID was administered in a controlled Web study (Reips, 2002) in which each participant was given 4 emotions randomly chosen from the set of 24 and asked to rate each in terms of the 144 emotion features. Using a 9-point scale ranging from *extremely unlikely* (1) to *extremely likely* (9), they rated the likelihood that each of the 144 emotion features can be inferred when a person from their cultural group uses the emotion term to describe an emotional experience. Each of the 144 emotion features was presented on a separate screen, and participants rated all 4 emotion terms for that feature before proceeding to the next feature.

Participants

In total, 198 Dutch-speaking students in Belgium (102 males, 96 females; average age = 20.88 years), 188 English-speaking students in the United Kingdom (74 males, 114 females; average age = 21.23 years), and 145 French-speaking students in Switzerland (37 males, 108 females; average age = 23.26) completed the GRID instrument in their own language.

RESULTS

To reduce the dimensionality of the emotion domain, we used principal component analysis (PCA), which finds the dimensions of greatest variance in the data set and represents each observation by its coordinates along each of these dimensions. PCAs were computed within and across the three languages, treating the 24 emotion terms as observations and the average scores on the 144 emotion features as variables.[1] A four-dimensional solution was selected on the basis of both the scree plots and the replicability of the configurations across the three languages (van de Vijver & Leung, 1997).[2] This solution accounted for 75.4% of the total variance. After varimax rotation, the first dimension (evaluation-pleasantness) accounted for 35.3% of the variance, the second dimension (potency-control) for 22.8%, the third dimension (activation-arousal) for 11.4%, and the last dimension (unpredictability) for 6.0%. This overall structure was replicated within each of the three language-culture samples.

The interpretation of the four dimensions is based on their relationships with the 144 emotion features and on the coordinates of the 24 emotion terms. Table 1 lists all 144 emotion features and their relationships to the four emotion dimensions (component loadings). Figure 1 represents the coordinates of the 24 emotion terms on these dimensions.[3] The first dimension can be interpreted as an evaluation-pleasantness dimension. Appraisals of intrinsic pleasantness and goal conduciveness, as well as action tendencies of approach versus avoidance or moving against, characterize this dimension. Pleasant emotions are opposed to unpleasant emotions on this dimension (see Fig. 1a). The second dimension is characterized by appraisals of control, leading to feelings of power or weakness; interpersonal dominance or submission, including impulses to act or refrain from action; changes in the rate and volume of speech; and parasympathetic symptoms. On this dimension, emotions such as pride, anger, and contempt are opposed to sadness, shame, and despair (see Fig. 1a). This dimension can therefore be interpreted in terms of potency-control. The third dimension is an activation-arousal dimension. It is mainly characterized by sympathetic arousal, such as rapid heartbeat and readiness for action. It opposes emotions such as stress, anger, and anxiety to disappointment, contentment, and compassion (see Fig. 1b). The last dimension is characterized by appraisals of novelty and unpredictability (and behaviors such as jaw dropping, eyebrow raising, and spontaneous exclamations), as compared with appraisals of expectedness or familiarity. Obviously, surprise is

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[1]Because there are only 24 emotion terms in the analysis, the variation in the 144 emotion features could be perfectly represented by a solution with 24 components. Thus, the matrix is not positive definite (the rank is only 24, not 144). Factor analyses (exploratory or confirmatory) that assume underlying factors cannot be used with these data, as these techniques require a positive definite matrix. PCA, however, is adequate, as it is a pure reduction technique. It makes sense to see whether a matrix of rank 24 can be further reduced to an even smaller number of components without losing much information. Analyzing a matrix with more variables than observations is not uncommon in lexical personality research. In that area of research, as here, the replicability and the reliability of the components are considered most important. A more extensive account of the analytic procedures is available from the first author.

[2]First, a structure was identified across the three languages. Then, a language-specific structure was computed and orthogonally Procrustes-rotated toward the overall structure. For each of the three language groups and for each of the four dimensions, the Tucker's phi congruence coefficient exceeded .90.

[3]The profiles of the emotion words on the four emotion dimensions can be requested from the first author.

TABLE 1

The 144 Emotion Features, the Components of Emotion They Represent, and Their Correlations With the Four Dimensions After Varimax Rotation

		Correlation			
Emotion feature	Emotion component[a]	D1	D2	D3	D4
Incongruent with own standards and ideals	Appraisal	**.926**	.201	.113	.180
Pressed lips together	Face	**.919**	.038	.245	−.086
Wanted to destroy whatever was close	Action	**.914**	.024	.206	−.022
Frowned	Face	**.914**	−.010	.172	.091
In itself unpleasant for the person	Appraisal	**.911**	.321	.103	.103
Wanted to do damage, hit, or say something that hurts	Action	**.908**	−.090	.183	−.011
Wanted to oppose	Action	**.907**	−.131	.195	.053
Consequences negative for person	Appraisal	**.905**	.325	.113	.103
Treated unjustly	Appraisal	**.901**	.172	.091	.212
Felt negative	Feelings	**.886**	.425	.078	−.005
Wanted to break contact with others	Action	**.871**	.354	.105	−.047
Violated laws or socially accepted norms	Appraisal	**.858**	.157	.133	.169
Felt the urge to stop what he or she was doing	Action	**.844**	.457	.109	.142
Wanted to undo what was happening	Action	**.843**	.491	.075	.041
Wanted to prevent or stop sensory contact	Action	**.843**	.454	.074	.064
Felt bad	Feelings	**.835**	.515	.084	.013
Felt inhibited or blocked	Action	**.805**	.491	.186	.094
Wanted to keep or push things away	Action	**.801**	.516	.110	.088
In itself unpleasant for somebody else	Appraisal	**.799**	.294	.026	.149
Consequences negative for somebody else	Appraisal	**.781**	.292	.020	.030
Withdrew from people or things	Gesture	**.760**	.546	.037	.009
Irrevocable loss	Appraisal	**.748**	.450	.117	.137
Moved against people or things	Gesture	**.745**	−.263	.287	.016
Wanted to run away in whatever direction	Action	**.709**	.602	.213	.120
Felt out of control	Feelings	**.702**	.241	.513	.136
Felt powerless	Feelings	**.695**	.619	.079	.162
Wanted to be in control of the situation	Action	**.677**	−.166	.348	−.105
In danger	Appraisal	**.675**	.333	.331	.332
Muscles tensing (whole body)	Body	**.674**	−.052	.636	.177
Tried to control the intensity of the emotional feeling	Regulation	**.669**	.415	.170	−.091
Felt exhausted	Feelings	**.653**	.644	.068	−.029
Consequences avoidable or modifiable	Appraisal	**.641**	−.006	.070	−.338
Hid the emotion from others by smiling	Regulation	**.617**	.581	.123	−.111
Wanted to be in command of others	Action	**.593**	−.497	.229	−.172
Inconsistent with expectations	Appraisal	**.527**	.219	.198	.486
Frequency of experience in the cultural group	Other	**−.321**	−.213	.257	−.245
Caused by a supernatural power	Appraisal	**−.364**	.023	.101	.285
Felt an urge to be attentive to what was going on	Action	**−.475**	−.419	.216	.104
Confirmed expectations	Appraisal	**−.539**	−.405	−.130	−.443
Familiar event	Appraisal	**−.587**	−.349	−.061	−.516
Felt in control	Feelings	**−.684**	−.615	−.127	−.254
Event with consequences the person was able to live with	Appraisal	**−.701**	−.324	−.076	−.187
Important and relevant for goals of somebody else	Appraisal	**−.702**	−.316	−.044	−.100
Important and relevant for the person's goals	Appraisal	**−.724**	−.278	−.001	−.126
In itself pleasant for somebody else	Appraisal	**−.727**	−.451	−.015	−.014
Person was at the center of attention	Appraisal	**−.730**	−.053	.370	−.038
Wanted to take care of another person or cause	Action	**−.739**	−.040	−.091	−.205
Consequences positive for somebody else	Appraisal	**−.757**	−.443	−.058	−.067
Wanted to go on with what he or she was doing	Action	**−.767**	−.536	−.026	−.147
Felt calm	Feelings	**−.771**	−.172	−.529	−.172
Wanted to comply with someone else's wishes	Action	**−.812**	.037	−.084	−.135
Wanted to get totally absorbed in the situation	Action	**−.815**	−.493	.032	−.049
Social acceptability of the emotion	Other	**−.819**	−.193	−.058	.111
Muscles relaxing	Body	**−.827**	−.128	−.368	−.108

Table 1. (Contd.)

Emotion feature	Emotion component[a]	Correlation			
		D1	D2	D3	D4
Felt at ease	Feelings	**−.882**	−.414	−.121	−.082
Wanted to be near or close to people or things	Action	**−.883**	−.145	−.072	−.032
Felt positive	Feelings	**−.887**	−.436	−.034	−.021
Wanted the ongoing situation to last or be repeated	Action	**−.901**	−.392	−.060	−.025
Felt good	Feelings	**−.905**	−.394	−.048	−.011
Consequences positive for person	Appraisal	**−.906**	−.345	−.078	−.070
Smiled	Face	**−.916**	−.341	−.014	−.029
Wanted to be tender, sweet, and kind	Action	**−.916**	−.056	−.198	−.128
Wanted to sing and dance	Action	**−.918**	−.329	.011	.003
In itself pleasant for the person	Appraisal	**−.925**	−.334	−.049	−.017
Wanted to submit to the situation as it was	Action	**−.930**	−.097	−.126	−.020
Decreased the volume of voice	Voice	.076	**.855**	−.360	−.145
Wanted to hand over the initiative to someone else	Action	.024	**.832**	.095	.079
Felt weak limbs	Body	.105	**.832**	.298	.209
Fell silent	Voice	.368	**.831**	−.102	.004
Felt submissive	Feelings	.426	**.825**	.049	−.036
Felt weak	Feelings	.542	**.803**	.012	.076
Wanted to make up for what he or she had done	Action	.220	**.766**	−.083	−.205
Wanted to withdraw into him- or herself	Action	.596	**.765**	.006	−.042
Lacked the motivation to do anything	Action	.535	**.740**	−.218	−.029
Wanted to do nothing	Action	.315	**.737**	−.321	−.071
Wanted to disappear or hide from others	Action	.655	**.713**	.057	−.031
Wanted someone to be there to provide help or support	Action	.498	**.700**	.065	.134
Closed his or her eyes	Face	.092	**.696**	−.164	.040
Spoke slower	Voice	.068	**.683**	−.572	−.132
Wanted to flee	Action	.672	**.679**	.160	.091
Got pale	Body	.589	**.675**	.158	.307
Had a feeling of a lump in the throat	Body	.422	**.671**	.228	.052
Wanted to be hurt as little as possible	Action	.533	**.663**	.123	−.081
Felt cold	Body	.562	**.650**	−.166	.207
Felt tired	Feelings	.598	**.633**	−.052	−.158
Had a trembling voice	Voice	.564	**.632**	.364	.068
Showed tears	Face	.067	**.628**	.112	.020
Had stomach troubles	Body	.600	**.610**	.391	.046
Showed the emotion to others less than he or she felt it	Regulation	.321	**.600**	.103	−.144
Lacked the motivation to pay attention to what was going on	Action	.436	**.591**	−.219	−.095
Will be changed in a lasting way	Other	−.107	**.557**	−.087	−.360
Wanted to act, whatever action it might be	Action	.376	**−.529**	.487	.009
Wanted to move	Action	−.085	**−.581**	.535	−.013
Produced a long utterance	Voice	−.310	**−.599**	.121	−.072
Moved toward people or things	Gesture	−.583	**−.599**	.123	.078
Showed the emotion to others more than he or she felt it	Regulation	−.248	**−.601**	−.069	.330
Caused intentionally	Appraisal	−.205	**−.649**	−.089	−.169
Wanted to show off	Action	−.606	**−.650**	.109	−.107
Felt alert	Feelings	−.100	**−.664**	.473	.166
Felt an urge to be active, to do something, anything	Action	−.184	**−.699**	.407	−.109
Felt powerful	Feelings	−.574	**−.702**	.093	−.182
Felt energetic	Feelings	−.624	**−.707**	.269	.019
Wanted to be seen, to be in the center of attention	Action	−.571	**−.711**	.114	−.112
Felt strong	Feelings	−.589	**−.733**	.111	−.142
Increased the volume of voice	Voice	.079	**−.777**	.460	.218
Wanted to tackle the situation	Action	.034	**−.786**	.242	−.064
Wanted to take initiative him- or herself	Action	−.093	**−.796**	.191	−.126
Felt dominant	Feelings	−.374	**−.822**	.127	−.183
Had an assertive voice	Voice	−.060	**−.908**	.072	−.105
Felt heartbeat getting faster	Body	−.019	−.210	**.927**	.100

Table 1. (Contd.)

Emotion feature	Emotion component[a]	Correlation			
		D1	D2	D3	D4
Felt breathing getting faster	Body	.260	−.099	**.893**	.161
Felt hot	Body	.189	−.077	**.850**	−.088
Sweated	Body	.339	.231	**.843**	.017
Perspired, or had moist hands	Body	.372	.272	**.799**	.005
Spoke faster	Voice	−.055	−.576	**.717**	.107
Produced abrupt body movements	Gesture	.217	−.356	**.688**	.419
Felt restless	Feelings	.397	−.115	**.688**	.066
Was in an intense emotional state	Feelings	.164	.151	**.647**	−.043
Felt shivers	Body	−.048	.157	**.647**	.403
Blushed	Body	−.402	−.049	**.602**	−.212
Felt nervous	Feelings	.541	.381	**.593**	.013
Felt warm	Body	−.413	−.420	**.558**	−.264
Produced speech disturbances	Voice	.520	.461	**.557**	.182
Opened her or his eyes widely	Face	−.254	−.464	**.537**	.496
Required an immediate response	Appraisal	.187	−.005	**.528**	.486
Wanted to overcome an obstacle	Action	.226	−.355	**.509**	−.161
Changed the melody of his or her speech	Voice	−.190	−.287	**.388**	.192
Did not show any changes in face	Face	.008	.085	**−.519**	−.358
Did not show any changes in vocal expression	Voice	−.252	.053	**−.578**	−.357
Did not show any changes in gestures	Gesture	−.017	.288	**−.585**	−.361
Felt breathing slowing down	Body	−.496	.102	**−.701**	−.096
Felt heartbeat slowing down	Body	−.208	.369	**−.715**	.006
Had no bodily symptoms at all	Body	−.154	−.072	**−.779**	.006
Had the jaw drop	Face	−.014	.105	−.129	**.798**
Had eyebrows go up	Face	−.018	−.291	.136	**.723**
Unpredictable event	Appraisal	.120	.153	.348	**.680**
Produced a short utterance	Voice	.399	−.057	.151	**.608**
Event occurred suddenly	Appraisal	−.058	.083	.400	**.589**
Caused by chance	Appraisal	−.516	−.150	.136	**.521**
Caused by somebody else's behavior	Appraisal	.396	−.335	.106	**.416**
Caused by the person's own behavior	Appraisal	−.532	−.126	.069	**−.599**
Consequences predictable	Appraisal	−.320	−.385	−.210	**−.621**
Person had enough resources to avoid or modify consequences of the event	Appraisal	−.027	−.199	.043	**−.632**
Experienced the emotional state for a long time	Feelings	−.089	.224	−.061	**−.755**

Note. For each feature, the highest loading is in boldface. D1 = evaluation-pleasantness dimension, D2 = potency-control dimension, D3 = activation-arousal dimension, D4 = unpredictability dimension.
[a]Action = action tendency, Body = bodily experience, Face = facial expression, Feelings = subjective experience, Gesture = gestural expression, Voice = vocal expression.

distinguished from all other emotions on this dimension. However, meaningful differentiations emerge among these other emotions as well; for example, fear is distinguished from stress and disgust from contempt (see Fig. 1c).

DISCUSSION

The results of this cross-cultural study provide robust evidence that more than two dimensions are needed for a low-dimensional representation of the semantic space of emotion. It is important to note that there were no major differences among the three language-culture groups. As suggested half a century ago, the three most important dimensions are evaluation-pleasantness, potency-control, and activation-arousal, in that order of impor-

tance. A fourth dimension, unpredictability, seems necessary to allow a satisfactory differentiation of emotions reflecting an urgent reaction to a novel stimulus or an unfamiliar situation. Although unpredictability has not emerged in most previous general studies of the dimensions of emotion, uncertainty is an important dimension in many appraisal theories (cf. Ellsworth & Scherer, 2003), and unexpectedness in the form of interruption was central to Mandler's (1975) model. In fact, the emergence of this factor in our comprehensive approach may explain the ambivalent status surprise has always had in the emotion pantheon, as it often co-occurs with and is confused with other emotions. Our results suggest that the term *surprise* may in fact refer to a particular quality or dimension of emotional experience based on appraisal of novelty and unexpectedness.
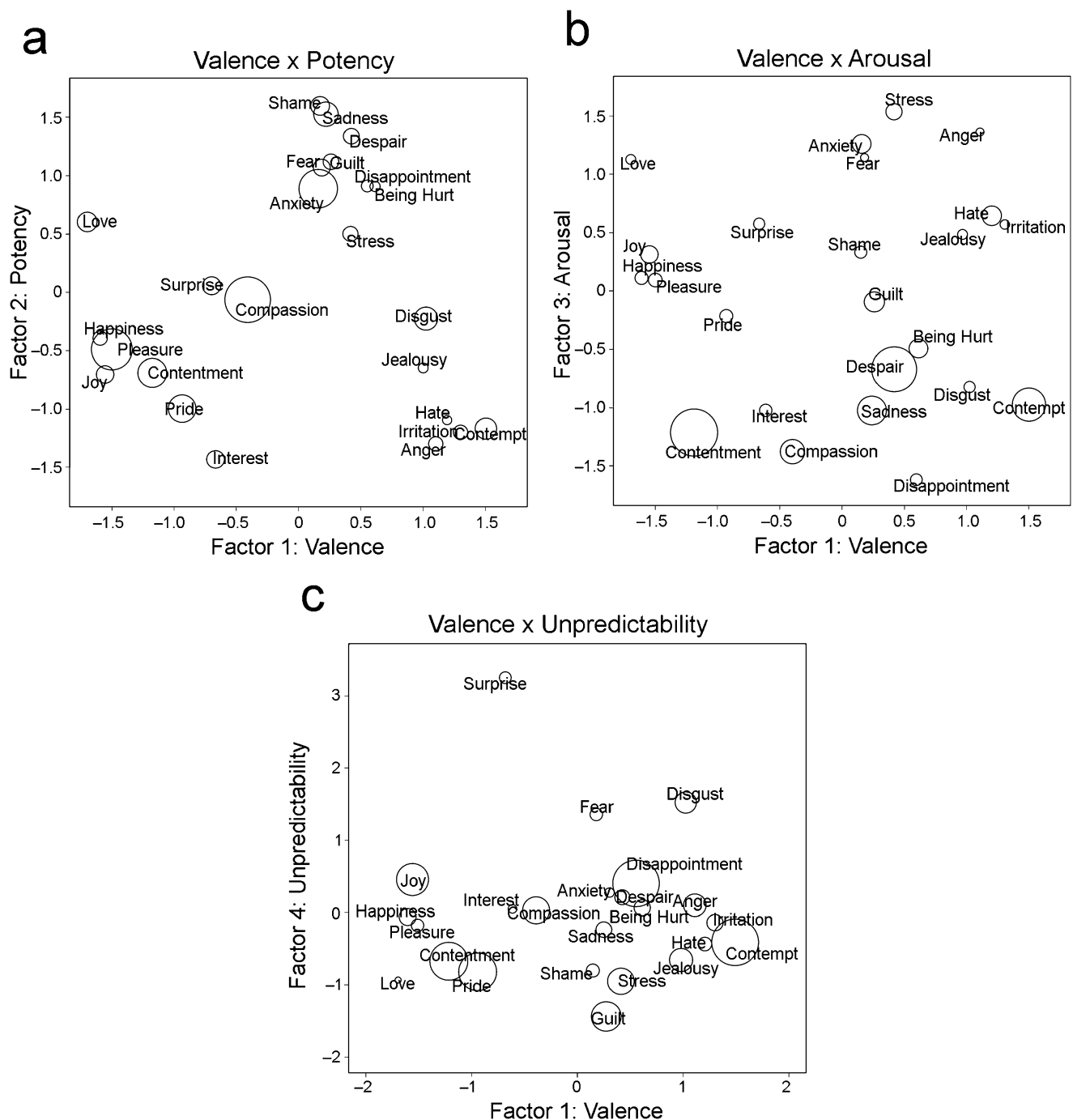
Fig. 1. The four-dimensional solution representing the 24 emotion terms. Midpoints of the circles represent the mean coordinates across the three languages. The diameter of each circle represents the mean euclidean distance among the coordinates for the three languages; the smaller the circle, the more similar the respective terms across the languages. The three panels show plots of coordinates for (a) Evaluation-Pleasantness × Potency-Control, (b) Evaluation-Pleasantness × Activation-Arousal, and (c) Evaluation-Pleasantness × Unpredictability.

The four-dimensional structure of emotion derived in the present research can be considered important because it is based not only on a representative sample of prototypical emotion labels, but also on a representative sample of features of emotional experience. This is the first study that has included all six of the major components of emotion identified by emotion researchers. The explanations as to why the same two or three emotion dimensions emerged in previous research were speculative. A major contribution of the present study is that it recovered the same three dimensions from a very precise analysis of the meaning of emotion terms, as rated on 144 specific criteria that most current emotion theorists explicitly assume are centrally relevant to the domain of emotions. Moreover, basing a dimensional analysis on comprehensive feature profiles for

different emotion terms allowed us to infer, for the first time, the features on which similarity judgments for emotion words and experiences are based and the subsets of those features that underlie specific dimensions (see Table 1). The complete profiles for the terms, with respect to both the 144 individual features and the four dimensions (not reported in this article), allow us to determine which features are essential for the meaning of a term and to compare terms across languages.

A limitation of the current study is that it included only student samples. Although the same overall emotion structure can be expected with representative adult samples—the students were asked not about their own experiences, but about the meaning of the emotion words in their culture—it is possible that slight differences exist between different age groups. For instance, in our student samples, *love* was scored high on arousal features. It is quite possible that the meaning of *love* is associated with less arousal in older age groups.

Moreover, because our research involved perceptions of the meanings of emotion words, it is obviously relevant to the meaning structure of the emotion domain in three *languages*. We cannot be sure that our findings represent the dimensions of emotional *experience*. Robinson and Clore (2002) have highlighted the distinction between current emotion, which is episodic, experiential, and contextual, and beliefs about emotion, which are semantic, conceptual, and decontextualized. Clearly, by design, our data on semantic profiles belong to the latter category. However, the fact that the same four dimensions emerged for all three language-culture groups suggests that the findings represent more than mere linguistic or cultural conventions. We are currently conducting research in a much larger sample of linguistic and cultural groups, including non-Western languages and cultures, and preliminary data confirm the patterns reported here. Although language is abstracted from human experience, it must correspond to human experience and represent important human concerns. Consequently, as the emotion words and features used in the present research are highly similar to those commonly used in procedures for assessing emotion, one would expect to find a similar four-factor structure in assessments of emotional experience. But this is for future research to show. Of course, a representative selection of emotion words and emotion features is a precondition for an emotion-experience instrument to uncover the same structure.

Given that the comprehensive approach reported here confirms the existence and the importance of the classic factors of valence and arousal, working with these two factors is not an issue of right or wrong choices. The optimal number of dimensions to be included in a study depends on the question the researcher is asking. For a researcher interested in the effects of sympathetic activation, one dimension (arousal) may be sufficient. For a researcher interested in the subtle distinctions among related emotions such as shame, guilt, embarrassment, and self-anger, four dimensions might not be enough. But for researchers interested in providing a fairly comprehensive

general account of the emotional experiences of the people they study, we strongly advocate using at least four dimensions.

Because models drive research design, restricting the number of emotion dimensions studied may severely bias the choice of methods and the interpretation of results. The current results imply that simple two-dimensional models, such as the valence-arousal model, miss major sources of variation in the emotion domain. Such models fail to differentiate important emotions like fear and anger (see Fig. 1b), which are clearly separated on the potency-control dimension (Fig. 1a) and on the unpredictability dimension (Fig. 1c). The potency-control dimension is of particular interest for emotion research. Its meaning is not limited to social and interpersonal experiences of dominance and submissiveness, as has been suggested in the past (e.g., Russell, 1991). It is also characterized by specific vocal response characteristics and action tendencies, such as wanting to take initiative versus being apathetic. Low potency-control is particularly relevant for emotion researchers who are interested in the biological underpinnings of emotions, as this dimension also captures parasympathetic forms of activation, such as weak limbs and gastrointestinal symptoms. The currently dominant two-dimensional models, such as the valence-arousal model, represent only sympathetic forms of activation (see Fig. 1b).

The findings of the present study have implications for very diverse forms of emotion research. For instance, experimental neuropsychological research designed to identify the brain processes underlying subjective emotional experiences requires a representative mapping of these subjective experiences. For many clinical and applied studies, it is crucial to distinguish whether a person is experiencing fear or anger, and two-dimensional models do not capture this distinction, which can be more adequately studied with the four-dimensional emotion model. Even for those researchers who are interested only in evaluation and activation, the four-dimensional model allows for better control of unintended variation on the two other emotion dimensions. Whereas two-dimensional models may be appropriate for studying some questions, researchers should seriously consider whether such models are sufficient for their particular questions.

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